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**Article**

**Keywords:** Chinese Medicine Formula Granule, Enterprise Innovation, Three-Stage DEA Model, Efficiency of Technology Innovation, Environmental Factors

**Posted Date:** July 1st, 2026

**DOI:** https://doi.org/10.21203/rs.3.rs-7127609/v1

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**Additional Declarations:** No competing interests reported.

# Research on technology innovation efficiency of TCM formula granule enterprises based on three-stage data envelope analysis model

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**Abstract:** In order to study the innovation efficiency of Chinese medicine formula granule enterprises, and provide impetus for the development of enterprises and the development of Chinese medicine industry. This paper takes the 13 listed enterprises of TCM formula granules approved by the state, provinces, and autonomous regions.And measures the innovation efficiency and influencing factors of TCM formula granule enterprises by three-stage data envelope analysis. The results show that the scale and efficiency of TCM formula granule enterprises are mostly in an increasing state, and the efficiency of technological innovation of enterprises is affected by the industrial structure, per capita GDP and government subsidies. Based on the above research, this paper believes that enterprises can optimize the allocation of resources by expanding the production scale, stabilizing the internal environment, creating an innovation atmosphere and other ways, which can improve the efficiency of enterprise technological innovation.

**Keywords:** Chinese Medicine Formula Granule; Enterprise Innovation; Three-Stage DEA Model; Efficiency of Technology Innovation; Environmental Factors;

## 1.Introduction

Traditional Chinese Medicine (TCM) formula granules, as a representative product of TCM modernization, currently have over 700 types in clinical use (1). Due to their convenience in carrying and exemption from complex decoction processes, they are gaining more access to international markets (2). In February 2021, TCM formula granules entered a golden development period. While the overall development of the TCM formula granules industry is crucial for enterprise growth, companies face issues such as reduced profit margins, product varieties that cannot meet clinical demands, and insufficient market competitiveness (3). Therefore, companies must innovate to enhance competitiveness, as innovation is the driving force for establishing competitive advantages (4). Scholars like Tugba (5) have emphasized the importance of innovation for corporate competitiveness. Thus, TCM formula granule enterprises need to improve their innovation capabilities and optimize resource allocation to promote development and maintain competitiveness in the market.

Given that technological innovation efficiency is a key indicator for evaluating innovation capabilities, research indicates it is crucial for assessing corporate and regional innovation (6, 7). However, existing studies mainly focus on the innovation efficiency of TCM industries and enterprises (3, 8, 9), with less attention on TCM formula granules specifically (10, 11). There is a lack of research on how to improve the innovation efficiency of TCM formula granule enterprises, which is vital for enhancing their competitiveness and human health.

TCM formula granule enterprises are faced with many deficiencies in innovation and development, The efficiency of technological innovation needs to be improved, By understanding the previous scholars' research on

affecting the efficiency of enterprise innovation, It can better grasp the influencing factors of the innovation efficiency of TCM formula granule enterprises, Many scholars explore the factors that affect the innovation efficiency from the enterprises themselves, View a positive correlation between R & D investment and innovation, Highlights the importance of R & D investment for innovation (12), Yinghua Lin (13) By analyzing the data of Chinese listed companies, Results show a positive correlation between R & D investment in innovation, Highlighting the importance of R & D investment for innovation. Moreover, scholars X. Ding (14), Panagiotis Pegkas, (15) and others have found that the R & D investment has a significant promotion effect on the total factor productivity of enterprises. However, the study of Chen Wei (16) found that increasing the R & D investment does not effectively improve the innovation efficiency between the factor input and innovation performance; secondly, Wolfgang Herb (17) and Zhenyu GONG (18) believe that the proportion of R & D expenditure has a huge impact on innovation efficiency; some scholars believe the influence of the number of R & D personnel on innovation efficiency (19). The above scholars analyze the influencing factors of enterprises or regions. In addition to themselves, environmental factors also have a huge impact on the innovation efficiency of enterprises. Scholars find that government subsidies (20), GDP (21), and industrial structure (22) all have an impact on technological innovation efficiency; however, scholars lack research on the innovation efficiency of TCM formula enterprises, and to explain the influence of environmental factors on enterprise investment.

This study focuses on TCM formula granule enterprises, using a three-stage DEA model to measure their technological innovation efficiency and analyze the impact of environmental variables. The aim is to propose strategies for improving enterprises' resistance to external environmental factors. It is suggested that the government should provide a good business environment for TCM formula granule enterprises and promote the development of TCM industry.

## 2.Literature Review and Research Hypotheses

### 2.1.Government Subsidies and Corporate Innovation Efficiency

Environmental variables significantly influence corporate innovation efficiency, with government subsidies being a key factor (23). Ge Ban (24) found that government subsidies enhance corporate innovation performance through R&D investment, and Zhang (25) noted their role in incentivizing R&D activities, particularly in small and medium-sized enterprises. Government subsidies also boost innovation in pharmaceutical enterprises (26, 27). However, their specific impact on TCM formula granule enterprises' innovation efficiency remains unexplored. This study uses a three-stage model to investigate this impact, proposing the following hypotheses:

H1: Environmental variables positively impact the innovation efficiency of TCM formula granule enterprises.

H2: Government subsidies enhance the innovation efficiency of TCM formula granule enterprises.

### 2.2. Per Capita GDP and Corporate Innovation Efficiency

China's TCM industry is influenced by policy support and economic conditions. Per capita GDP may affect TCM enterprises' innovation efficiency through resource allocation, policy support, and market demand (28). High per capita GDP regions often have stronger fiscal capabilities to implement policies, such as eastern provinces excelling in technology transfer and market expansion (29, 30). However, policy implementation in central and western regions is constrained by weaker economic foundations, leading to uneven innovation resource distribution and lower innovation efficiency (31). While existing research indicates that per capita GDP influences TCM enterprise innovation efficiency, specific analyses targeting TCM formula granule enterprises are lacking. Therefore, this study proposes:

H3: Per capita GDP promotes the innovation efficiency of TCM formula granule enterprises.

### 2.3. Industrial Structure and Corporate Innovation Efficiency

Industrial structure, defined as the proportion of the secondary industry in this study (32), is a critical

environmental variable affecting corporate innovation efficiency. Research shows that a diversified and advanced industrial structure significantly enhances innovation efficiency, especially in manufacturing and services (33). Optimizing the industrial structure helps enterprises cope with environmental regulations and improve innovation efficiency (34). For pharmaceutical enterprises, optimizing the secondary industry proportion can boost innovation efficiency(35). Thus, this study hypothesizes:

H4: Optimization of the industrial structure promotes the innovation efficiency of TCM formula granule enterprises.

## 3.Data and Methods

### 3.1. Data Sources

As of early 2021, there were 76 national and provincial pilot production enterprises for TCM formula granules across 25 provinces. This study selects 13 listed TCM formula granule enterprises with a certain scale from these pilot enterprises. Data are sourced from statistical yearbooks and annual reports of various regions and enterprises, covering the period from 2018 to 2022.

### 3.2.Variable Selection

For the three-stage DEA evaluation, input variables include R&D investment, R&D investment ratio, and number of R&D personnel (36). Output variables are annual invention patents and utility model patents. Environmental variables are per capita GDP, industrial structure, and government financial subsidies.

### 3.3. Analytical Methods

The study employs a three-stage DEA model. In 1978, the traditional DEA model was created by Charnes and Cooper (37). Fried (38) believed that the original model did not consider the influence of environmental factors and the random error term, and should separate the environmental factors from the random error term, and then create a three-stage DEA model,

Phase 1: Build the initial DEA model. Enter the initial input variables and output variables into Deap 2.1 software, and use the BCC (Banker, Charnes, Cooper) model with variable scale reward to obtain the technical efficiency, pure technical efficiency, and scale efficiency. Because CCR (A. Charnes & W. W. Cooper. E. Rhodes) model can only get technical efficiency, so Bnker (39) to improve CCR model scale variable BCC model, technical efficiency into pure technical efficiency and scale efficiency, namely technical efficiency is equal to the product of pure technical efficiency and scale efficiency (40).

Stage 2: Building a stochastic frontier model (Stochastic Frontier Approach, SFA). To decompose the relaxation variable into a function of three independent variables including environmental, random, and management factors (41):

$$S_{ij} = f(Z_i;\beta_j) + V_{ij} + \mu_{ij}; i = 1,2,\cdots I; j = 1,2,\cdots N$$

Its purpose is to adjust the input difference value and remove the influence of environmental factors. $S_{ij}$ is the input relaxation value of j unit i, $Z_i$ is the environmental variable; $\beta_j$ is the coefficient of the environmental variable; $V_{ij} + \mu_{ij}$is the comprehensive interference; $V_{ij}$ is the random factor, following the normal distribution; $\mu_{ij}$ is the management factor, i. e. the management efficiency, following the normal distribution for the stage. The estimation formula of management efficiency is as follows:

$$E(u|\varepsilon) = \int_0^{\infty} = uf(u|\varepsilon)\,du = \frac{E(X^{n+1})}{E(X^n)}$$

Subsequently, the SFA regression results are used to solve the decision unit DMU (Decision Making Units), and the adjusted input makes each DMU in the same environment:

$$X_{ij}^{A} = X_{ij} + [\max(f(Z_i;\beta_n)) - f(Z_i;\beta_n)] + [\max(V_{ij}) - V_{ij}]$$

$X_{ij}^{A}$ is the input after adjustment, $X_{ij}$ is the input before adjustment, max (f ($Z_i$; $\beta_n$)) -f ($Z_i$; $\beta_n$) is the adjustment of environmental factors, and max ($V_{ij}$) -$V_{ij}$ is the adjustment of the random error term.

Stage 3: Adjusted DEA model. The input value and initial output value excluding environmental variables and random error items are replaced in the first stage DEA model, and the relative efficiency of each DMU is calculated again. At this time, the efficiency value obtained can more accurately reflect the management inefficiency of DMU

### 3.4. Descriptive statistical analysis

Descriptive statistics for input and output variables as well as environmental variables are shown in Table 1. Among them, the minimum value of both output variables is 0, indicating that the enterprise output index value is not ideal and may be affected by multiple factors. The standard deviation between r & d investment and government subsidy is high, indicating that the investment level of different enterprises is significant, and the degree of government subsidy to enterprises is also different.

Table 1: Descriptive statistics for each variable

| | variable quantity | definition | average value | median | standard deviation | least value | crest value |
|---|---|---|---|---|---|---|---|
| output-input ratio | Number of current invention patents (n) | The number of enterprise invention patents in the same year | 15.40 | 3.00 | 31.35 | 0.00 | 202.00 |
| | Number of current utility model patents (n) | The number of utility model patents in the enterprise | 4.77 | 1.00 | 9.07 | 0.00 | 47.00 |
| put into | R & D investment (ten thousand yuan) | The investment the company made in research and development | 34655.38 | 14400.00 | 55617.40 | 10.00 | 197193.94 |
| | The proportion of R & D expenditure is (%) | The proportion of R & D investment in operating revenue | 0.04 | 0.04 | 0.05 | 0.00 | 0.43 |
| | Number of RD personnel (person) | The number of enterprise R & D personnel | 699.00 | 501.00 | 868.34 | 37.00 | 5002.00 |
| environment | Per capita GDP (ten thousand yuan / person) | Per capita income level in the city where the enterprise is located | 10.95 | 11.93 | 5.77 | 2.70 | 20.04 |
| | industrial structure (%) | The proportion of secondary industry | 32.00 | 35.00 | 7.00 | 16.00 | 52.00 |
| | Government fund subsidy (ten thousand yuan) | The government subsidized the enterprises that year | 10878.72 | 5964.29 | 13952.21 | 446.77 | 64988.55 |

## 4.Empirical Analysis

### 4.1. Traditional DEA Analysis Results

Using DEAP2.1, the study evaluates the innovation efficiency of 13 listed TCM formula granule enterprises from 2018 to 2022. The results are shown in Table 2, showing that from 2018 to 2021, technological and scale efficiency gradually improved, albeit at a lower level. In 2022, some enterprises experienced a decline in technical efficiency, possibly due to national policy requirements for production capacity upgrades and increased R&D investment. Overall, the average values for technical efficiency, pure technical efficiency, and scale efficiency are

0.5214, 0.8332, and 0.5778, respectively, indicating low resource utilization efficiency.

1 Table 2 Efficiency values of each decision unit

| DMU | 2018 | | | | 2019 | | | | 2020 | | | | 2021 | | | | 2022 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | technical efficiency | pure technical efficiency | Scale efficiency | return of scale | technical efficiency | pure technical efficiency | Scale efficiency | return of scale | technical efficiency | pure technical efficiency | Scale efficiency | return of scale | technical efficiency | pure technical efficiency | Scale efficiency | return of scale | technical efficiency | pure technical efficiency | Scale efficiency | return of scale |
| China Resources sanjiu | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - |
| Beijing Kangrentang Pharmaceutical Co | 0.042 | 0.423 | 0.099 | irs | 0.068 | 0.405 | 0.169 | irs | 0.049 | 0.445 | 0.110 | irs | 1.000 | 1.000 | 1.000 | - | 0.925 | 1.000 | 0.925 | drs |
| Ma Yinglong Pharmaceutical | 0.125 | 1.000 | 0.125 | irs | 0.198 | 1.000 | 0.198 | irs | 0.211 | 1.000 | 0.211 | irs | 0.822 | 1.000 | 0.822 | irs | 0.976 | 1.000 | 0.976 | irs |
| Kangmei Pharmaceutical | 0.158 | 1.000 | 0.158 | irs | 0.225 | 1.000 | 0.225 | irs | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - |
| Fragrant snow pharmaceutical | 1.000 | 1.000 | 1.000 | - | 0.091 | 0.585 | 0.155 | irs | 0.195 | 0.474 | 0.412 | irs | 0.449 | 0.751 | 0.598 | irs | 0.591 | 0.788 | 0.750 | irs |
| Guiyang Xintian Pharmaceutical | 1.000 | 1.000 | 1.000 | - | 0.356 | 1.000 | 0.356 | irs | 1.000 | 1.000 | 1.000 | - | 0.299 | 1.000 | 0.299 | irs | 0.000 | 1.000 | 0.000 | irs |
| Guizhou Yibai Pharmaceutical | 0.427 | 1.000 | 0.427 | irs | 0.393 | 1.000 | 0.393 | irs | 0.138 | 1.000 | 0.138 | irs | 0.320 | 0.447 | 0.716 | irs | 0.668 | 0.732 | 0.912 | drs |
| Shanghai Kaibao Xinyi Pharmaceutical | 0.104 | 0.887 | 0.118 | irs | 1.000 | 1.000 | 1.000 | - | 0.238 | 0.508 | 0.469 | irs | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Company | | | | | | | | | | | | | | | | | | | | |
| Tasly Northeast Modern Traditional Chinese Medicine Co., LTD | 0.194 | 0.366 | 0.531 | irs | 0.128 | 0.373 | 0.343 | irs | 1.000 | 1.000 | 1.000 | - | 0.000 | 0.193 | 0.000 | irs | 0.129 | 0.230 | 0.563 | irs |
| Jewel Island Pharmaceutical | 0.964 | 1.000 | 0.964 | irs | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - | 1.000 | 1.000 | 1.000 | - |
| Beijing Tongrentang | 0.103 | 0.895 | 0.115 | irs | 0.131 | 0.883 | 0.148 | irs | 0.050 | 0.848 | 0.059 | irs | 0.225 | 0.797 | 0.282 | irs | 0.732 | 0.780 | 0.939 | irs |
| Jilin Aodong Liyuan Pharmaceutical Company | 0.097 | 0.703 | 0.138 | irs | 0.144 | 0.548 | 0.262 | irs | 0.129 | 0.703 | 0.184 | irs | 0.000 | 0.563 | 0.000 | irs | 0.000 | 0.591 | 0.000 | irs |
| Shanghai medicine | 0.194 | 1.000 | 0.194 | irs | 1.000 | 1.000 | 1.000 | - | 0.093 | 0.672 | 0.138 | irs | 0.521 | 0.523 | 0.996 | drs | 1.000 | 1.000 | 1.000 | - |
| average | 0.416 | 0.867 | 0.451 | | 0.441 | 0.830 | 0.481 | | 0.470 | 0.819 | 0.517 | | 0.590 | 0.790 | 0.670 | | 0.690 | 0.860 | 0.770 | |

1 Note：“irs”is an increase in the scale reward;“-”is the same for the scale of the remuneration.

4.2.SFA Regression Analysis Results

The regression results of SFA in the second stage are shown in Table 3. The analysis reveals that per capita GDP, industrial structure, and government subsidies significantly influence innovation efficiency. Per capita GDP shows positive correlations with R&D investment and labor redundancy, while industrial structure demonstrates negative correlation with R&D investment redundancy but maintains a positive correlation with labor redundancy. Government subsidies exhibit positive correlation with R&D investment redundancy but show a negative correlation with labor redundancy.

Table 3, Stage II SFA results

| | R & D investment redundancy (ten thousand) | The proportion of R & D expenditure is redundant to (%) | R & D personnel redundancy (person) |
|---|---|---|---|
| Per capita GDP (ten thousand yuan / person) | 1 095.386 8***(1 095.40) | 0.000 7(0.00) | 13.476 7***(14.78) |
| industrial structure | -2 819.496 3***(-2819.50) | 0.015 5(0.02) | 200.908 4***(200.88) |
| Government fund subsidy (ten thousand yuan) | 0.6823***(45.33) | -0.0000(-0.00) | -0.001 3(-1.35) |

Note：1)***Significant levels up to 1%,**Significant levels up to 5%,*Significant levels up to 10%,Inside the parentheses is the t-value

4.3. Third-Stage DEA Analysis Results

After adjusting for environmental variables and random errors, the empirical results shown in Table 4 indicate a 25% decrease in average technical efficiency and a 22.4% decline in scale efficiency. This demonstrates that both environmental variables and random errors significantly impact both technical and scale efficiency, with some enterprises experiencing substantial drops in technical efficiency post-adjustment. Figure 1 illustrates the comparison of technological innovation efficiency across enterprises before and after adjustments, highlighting the notable influence of external factors.

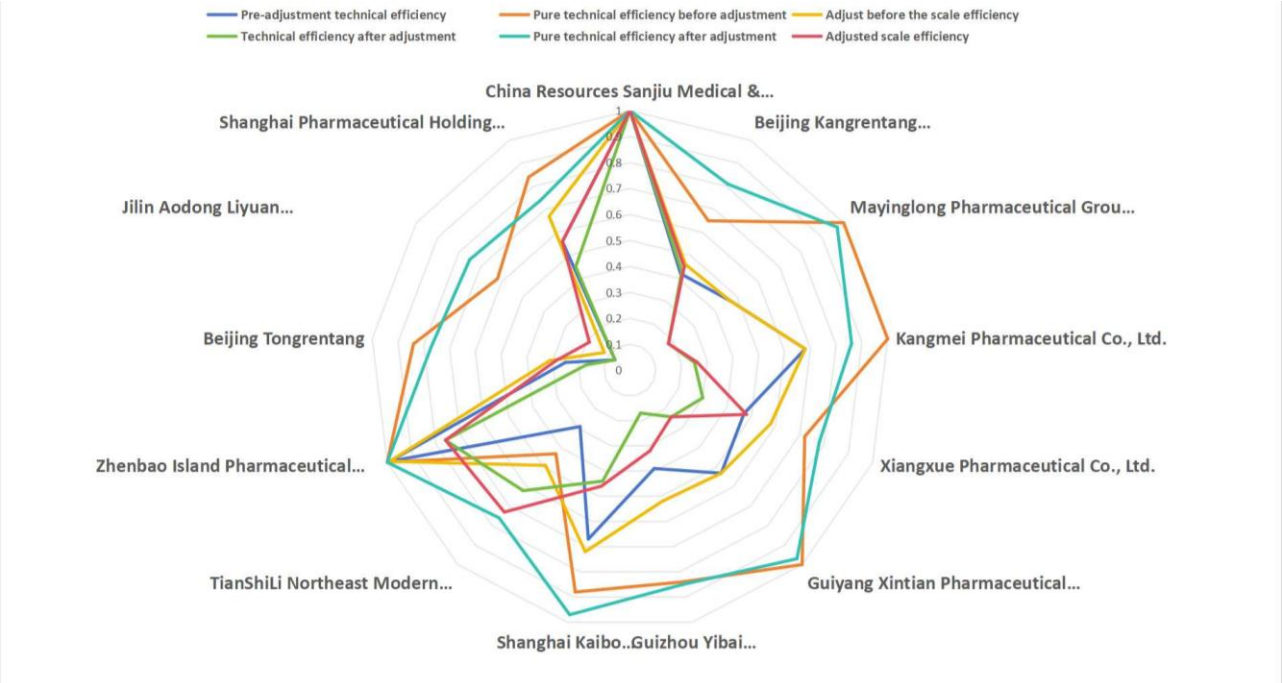



**Figure 1** Radar diagram of the technical efficiency of TCM formula granule enterprises

before and after the three-stage DEA adjustment

**Table 4** Comparison before and after enterprise innovation efficiency adjustment

| enterprise | Pre-adjustment technical efficiency | Pure technical efficiency before adjustment | Adjust before the scale efficiency | Technical efficiency after adjustment | Pure technical efficiency after adjustment | Adjusted scale efficiency |
|---|---|---|---|---|---|---|
| China Resources sanjiu | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Beijing Kangrentang Pharmaceutical Co | 0.42 | 0.65 | 0.46 | 0.43 | 0.81 | 0.45 |
| Mayinglong Pharmaceutical Group Co., Ltd | 0.47 | 1.00 | 0.47 | 0.18 | 0.97 | 0.18 |
| Kangmei Pharmaceutical | 0.68 | 1.00 | 0.68 | 0.25 | 0.86 | 0.26 |
| Fragrant snow pharmaceutical | 0.47 | 0.72 | 0.58 | 0.30 | 0.78 | 0.48 |
| Guiyang Xintian Pharmaceutical Co., Ltd | 0.53 | 1.00 | 0.53 | 0.24 | 0.97 | 0.24 |
| Guizhou Yibai Pharmaceutical Co., Ltd | 0.39 | 0.84 | 0.52 | 0.17 | 0.85 | 0.32 |
| Shanghai Kaibao Xinyi Pharmaceutical Company | 0.67 | 0.88 | 0.72 | 0.44 | 0.97 | 0.46 |
| Tasly Northeast Modern Traditional Chinese Medicine Co., LTD | 0.29 | 0.43 | 0.49 | 0.62 | 0.76 | 0.73 |
| Jewel Island Pharmaceutical | 0.99 | 1.00 | 0.99 | 0.76 | 1.00 | 0.76 |
| Beijing Tongrentang | 0.25 | 0.84 | 0.31 | 0.17 | 0.77 | 0.29 |
| Jilin Aodong Liyuan Pharmaceutical Company | 0.07 | 0.62 | 0.12 | 0.07 | 0.75 | 0.19 |
| Shanghai medicine | 0.56 | 0.84 | 0.67 | 0.45 | 0.74 | 0.56 |
| average | 0.52 | 0.83 | 0.58 | 0.39 | 0.86 | 0.45 |

## 5.Discussion and Hypothesis Verification

According to the results of the first stage, the scale efficiency of Mayinglong Pharmaceutical Group Co., Ltd., Beijing Tongrentang, Jilin Aodong Liyuan Pharmaceutical Co., Ltd. increases; the remaining 10 enterprises are always constant in scale or increase, which may be related to the change of the local environment and the development stage of the enterprise. It indicates that the TCM granule enterprises are in the rising period and have great development potential, and the environment has a great impact on the efficiency of technological innovation. It indicates that the enterprises can expand the production scale and reduce the average cost, so that the TCM granule enterprises can get better development. In the first stage of DEA analysis, only one TCM formula granule enterprise has reached the forefront of innovative technology. On the whole, there are great differences in the comprehensive efficiency value among various enterprises, and the resource use efficiency of most TCM formula granule enterprises is very low.

In the second stage of SFA regression analysis, the per capita GDP and the three investment redundancy indicators, which were positively correlated with the R&D investment and the redundancy of R&D personnel, indicating that the increase of GDP per capita may reduce the technical efficiency of TCM formula granule

enterprises, assuming that H3 is not established.

The negative correlation between industrial structure and the redundancy of R & D investment is positively correlated with the redundancy of personnel investment, while the negative correlation between the redundancy of R & D investment is significantly greater than the number of R & D personnel. Therefore, the optimization of industrial structure promotes the innovation efficiency of TCM formula granule enterprises. H4 was established. It may be that the manufacturing boom will gather more technical personnel to push up redundancy, while talent expansion will force enterprises to improve the efficiency of the use of funds, thus reducing investment redundancy.

The government fund subsidy is significantly positively correlated with the redundancy of RESEARCH and R&D investment, indicating that the government subsidy may reduce the innovation efficiency of TCM formula granule enterprises. H2 is not established. Although the increase of government funds can reduce the redundancy of R&D personnel and activate innovation efficiency, it will push up the redundancy of R&D investment. Although subsidies can attract talent, if the lack of effective incentive mechanism and capital supervision, it is easy to cause waste of resources and inhibit the improvement of innovation efficiency. Mayinglong Pharmaceutical Group Co., Ltd, Kangmei Pharmaceutical Co., Ltd,Guiyang Xintian Pharmaceutical Co., Ltd, Guizhou Yibai Pharmaceutical Co., Ltd, Shanghai Kaibo Newyi Pharmaceutical Co., Ltd, Zhenbao Island Pharmaceutical Co., Ltd, Shanghai Pharmaceutical Holding (Group) Co., Ltd, and other seven Chinese medicine formula enterprises in the influence of environmental variables and random error, technical efficiency is reduced, shows that environmental variables can promote the efficiency of technology innovation of Chinese medicine formula enterprises. H1 was established. However, the technological innovation efficiency value of China Resources Sanjiu, Beijing Kangrentang Pharmaceutical, and Beijing Tongrentang did not change much before and after the adjustment, which may be related to the enterprise's own innovative enterprise culture or its own development stage. Eliminate the influence of environmental variables, part of the enterprise technology efficiency change is not so obvious, the influence of the environmental intervention for enterprise innovation, may encourage innovation with the corresponding incentive system, but has not reached the frontier level, which requires enterprises combined with the environment to develop more scientific and effective system to ensure the enterprise innovation efficiency reached the forefront level.

## 6.Suggestions

### 6.1.Expand the production scale of enterprises

Through 20 years of experience in the pilot work of TCM formula granules, the state has issued a number of incentive documents in terms of macro-control, clearly proposing the project of TCM quality improvement and industry promotion, to promote the high-quality development of TCM industry. TCM formula granule enterprises should grasp the opportunities and national policies, conform to the development trend, make full use of the advantages of increasing scale efficiency, expand the production scale, increase capital and personnel investment, reduce the average cost, and improve the production and research and development benefits of enterprises. At the same time, to improve the management level of TCM formula granule enterprises and expand the production scale, it is necessary to strictly plan the production and research and development progress, ensure the rational utilization of production factors and improve the technical efficiency, so as to improve the development speed of TCM formula granule enterprises.

### 6.2.Build a stable internal and external environment

Through the empirical analysis, it can be found that the external environment has a great influence on the TCM formula granule enterprises. The market has the ability to regulate independently, so enterprises need to build a characteristic promotion and incentive system according to their own development needs, and improve the salary and performance appraisal system. At the same time, the resource allocation of TCM formula granule

enterprises is related to the performance of departments, so as to ensure the rationality of resource allocation and the high efficiency of asset utilization while increasing the investment, so as to promote the benign development of enterprises without relying on the external environment. In addition, the government can optimize the industrial structure, market environment, economic environment, resource allocation, and other channels to formulate policies conducive to the development of TCM formula granule enterprises, improve the innovation ability of enterprises, and escort the rapid development of TCM formula granule enterprises.

6.3.Create an atmosphere for enterprise innovation

From the analysis, we can see that the construction of an innovation environment has a great impact on the utilization efficiency of enterprise resources. A good environment for scientific and technological innovation can help professional and technical personnel to conduct innovative research, so as to improve the efficiency of enterprise technological innovation. On the basis of improving the construction of TCM infrastructure, we should strengthen the construction of experimental equipment and introduce advanced technology and equipment. We should give full play to our regional advantages, create an innovative business environment and a high-quality working environment, attract more innovative talents, and realize the effective utilization and rational allocation of resources. Enterprises themselves should more actively encourage professional and technical personnel to make innovative attempts, combine the government incentive policies and subsidy projects, improve the enterprise management mode, attract high-tech talents, and at the same time, stimulate their innovation power, and help the innovative development of TCM formula enterprises. Under the guidance of traditional theories of traditional Chinese medicine, the primary processing of producing areas can further improve the safety and effectiveness of TCM formula particles, promote the sustainable and healthy development of the traditional Chinese medicine industry, and promote traditional Chinese medicine to the world.

Data availability statement

The data that support the findings of this study will be available in mendeley data. doi: 10.17632/ndnkb7bdg5.1

Author contributions

SC and YHJ contributed to conception and design of the study.YHJ, LXR and ZTT collected the data. YHJ and LXR performed the statistical analysisand wrote the frst draft of the manuscript. All authors contributedto manuscript revision, read, and approved the submitted version.

Funding

This study was supported by Key Research Project of Anhui University of Traditional Chinese Medicine (2021rwzd09), Key Project of Humanities and Social Science Research of Anhui Universities (SK2021A0338),Key Project of Outstanding Young Talents in Anhui Universities (gxyqZD2022050).

Conflict of interest

The authors declare that the research was conducted in theabsence of any commercial or fnancial relationships that could beconstrued as a potential conflict ofinterest.

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